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(54) A SECOND-ORDER MASS-COMPENSATING MEANS FOR RECIPROCATING PISTON ENGINES

(71) We, KLOCKNER - HUMBOLDT - DEUTZ AKTIENGESELLSCHAFT, a German Body Corporate, of Köln-Deutz, German Federal Republic, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a second-order mass compensating or balancing means for reciprocating piston engines, for example internal-combustion reciprocating piston engines.

Second-order mass-compensating means are known in which two counter-weights disposed below the engine crankshaft are rotated in opposite directions at twice the engine speed, the rotating weights being located at approximately the longitudinal centre of the engine, mounted on two shafts which are disposed parallel to the crankshaft in a plane perpendicular to the longitudinal plane of the engine. The shafts are in driving engagement with one another via gearwheels of identical size secured thereto and have ends which project outwardly beyond the counterweights and the gearwheels. The ends of the shafts are journalled in supports, and one of the shafts is driven by the crankshaft. Examples of these second-order mass-compensating or balancing means, which have been described in detail and are in general use in internal-combustion reciprocating piston engines, have been disclosed in the patent literature, for example in German Patent Specifications 975,104; 959,861; 1,177,408; and 1,196,012.

The constructions disclosed in the above-mentioned patent specifications have one feature in common, namely that the counter-weights and the gearwheels are in the immediate spatial neighbourhood of one another. This is apparently the reason why the mass-compensating transmission system is very noisy in operation. The centrifugal forces produced by the counter-weights cause the shafts to move eccentrically in their bearings because of the clearance therein, the amount of eccentricity depending on the speed of rotation. The eccentric motion of the shafts in their bearings has a very disadvantageous effect on the engagement of the two gearwheels. Moreover, the tooth engagement varies continuously as the wheels rotate, more particularly in vehicle engines operated at greatly varying speeds, resulting in a clearly audible rattle. Such varying engagement of the two gearwheels also causes severe wear, which is very undesirable.

It is therefore an aim of the present invention to avoid the rattling produced by the gearwheels and the undesirable wear mentioned above. With this aim in view, the invention is directed to a reciprocating piston engine having dynamic balancing means, the balancing means comprising two rotatable shafts disposed one beside the other and parallel to a crankshaft of the engine, the shafts lying on that side of the crankshaft remote from the engine cylinder or cylinders with each shaft having a balance weight and a gear wheel secured thereto for rotation therewith, the gear wheels meshing with one another so that the shafts are coupled to rotate in opposite directions, and one of the shafts being coupled to the crankshaft so as to be rotatably driven at twice the speed of the crankshaft, wherein the two balance weights are disposed in the region of the longitudinal centre of the engine, and the two gear wheels are disposed adjacent an end of the engine, and wherein each shaft is supported at one end in a bearing which is immediately adjacent the balance weight and is supported at its other end in a bearing which is immediately adjacent the gear wheel.

Experimental assemblies, from which the invention was developed, have shown that the noise can be reduced to a minimum by separating the balance weights from the gearwheels. Since, according to the invention, the gearwheels are at a relatively large distance from the respective balance weights, the eccentric motion of the shafts in their bearings resulting from the centrifugal forces of the weights no longer has any appreciable effect on the mutual engagement of the gearwheels.

It has also been found that the harmful noise can be advantageously reduced if the shafts are hollow.

Since, according to the invention, the engagement of the gearwheels is kept substantially constant, the gearwheels are no longer subject to appreciable wear. The invention provides further advantages however. The mass-compensating, i.e. dynamic balancing, transmission system no longer needs to be assembled with the extreme care which was previously necessary. Since the shafts are longer, it is no longer necessary for the bearings to be in dead true alignment, and the gear tooth clearance can be adjusted more easily, when necessary, without adversely affecting the transmission system, by adjusting one of the mounting supports.

An embodiment of the invention is shown by way of example in the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section, in as much detail as is necessary for understanding the invention, of a second-order mass-compensating means for reciprocating piston engines;

Figure 2 shows a cross-section taken on the line II-II in Figure 1; and

Figure 3 is a view of the device shown in Figure 1 and 2, taken on the arrow III in Figure 2.

The second-order mass-compensating means shown in the drawings is designed for a four-cylinder Diesel engine. The mass-compensating means comprises two counter-weights (i.e. balance weights) 1 and 2 rotated in opposite directions at twice the engine speed. The counter-weights 1, 2 are disposed on two shafts 3, 4 and are in the region of the longitudinal centre of the engine, as is necessary for balancing, the said two shafts being disposed one beside the other and parallel to the crankshaft in a plane perpendicular to the longitudinal centre plane of the engine. The two shafts 3 and 4 lie on that side of the crankshaft remote from the engine cylinder or cylinders, which means that they will usually be located below the crankshaft. The shafts 3, 4 are in driving engagement with one another *via* gearwheels 5, 6 which are of the same size and are firmly secured to their respective shafts. In addition, the shafts have ends 7, 8 and 9, 10 which project outwards beyond the counter-weights 1, 2 and gearwheels 5, 6 with respect to the space between the counter-weights and gearwheels, and are journalled in mounting supports. The mounting supports are bars or girders 11, 12, the ends of which (not shown) are screwed to the side walls of the engine frame.

Figures 1 and 3 show a gearwheel 13 in driving engagement with a gearwheel disposed at one end of the crankshaft. Wheel 13 serves as an intermediate gearwheel for driving the mass-compensating means. To this end, a gearwheel 14 disposed at the end of shaft 3 engages the gearwheel 13. The gearwheel 13 is disposed on that side of bar 12 remote from gearwheel 5. As can be seen more particularly in Figures 1 and 2, the shafts 3, 4 extend to that end face of the engine which is adjacent the gearwheels 5, 6, so that the gearwheels 5, 6 are in the immediate neighbourhood of bearings in the bar 12 disposed there. Also the balance weights 1, 2 are immediately adjacent the bearings in the bar 11.

The shafts 3, 4 are hollow. It has been found that hollow shafts considerably help to reduce the noise produced by the mass-compensating means. The gearwheel 14 is secured to the shaft 3 on a reduced-diameter portion 15 which is located at one end of shaft 3 and which, for part of its length, is in the form of a necked-down bolt bearing a nut 17 for tightening gearwheel 14.

The intermediate gearwheel 13 is borne on a stub shaft or pin 19 in an extension 18 of bar 12. The mass-compensating transmission system is connected to the lubrication system of the Diesel engine. Lubricating oil is conveyed through the transmission system *via* the interiors of shafts 3, 4, by ducts 20, 21 in bar 11, and by a duct 22 in the extension 18. The ducts are connected by transverse bores 23 in the shafts 3, 4.

WHAT WE CLAIM IS:—

1. A reciprocating piston engine having dynamic balancing means, the balancing means comprising two rotatable shafts disposed one beside the other and parallel to a crankshaft of the engine, the shafts lying on that side of the crankshaft remote from the engine cylinder or cylinders with each shaft having a balance weight and a gear wheel secured thereto for rotation therewith, the gear wheels meshing with one another so that the shafts are coupled to rotate in opposite directions, and one of the shafts being coupled to the crankshaft so as to be rotatably driven at twice the speed of the crankshaft, wherein the two balance weights are disposed in the region of the longitudinal centre of the engine, and the two gear wheels are disposed adjacent an end of the

engine, and wherein each shaft is supported at one end in a bearing which is immediately adjacent the balance weight and is supported at its other end in a bearing which is immediately adjacent the gear wheel.

2. A reciprocating piston engine according to claim 1, wherein the two shafts are hollow.

3. A reciprocating piston engine having dynamic balancing means substantially as described herein with reference to and as illustrated by the accompanying drawings.

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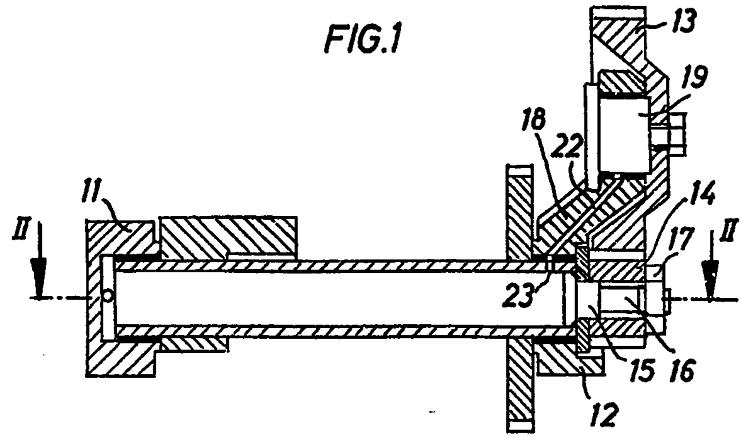
1367831 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1



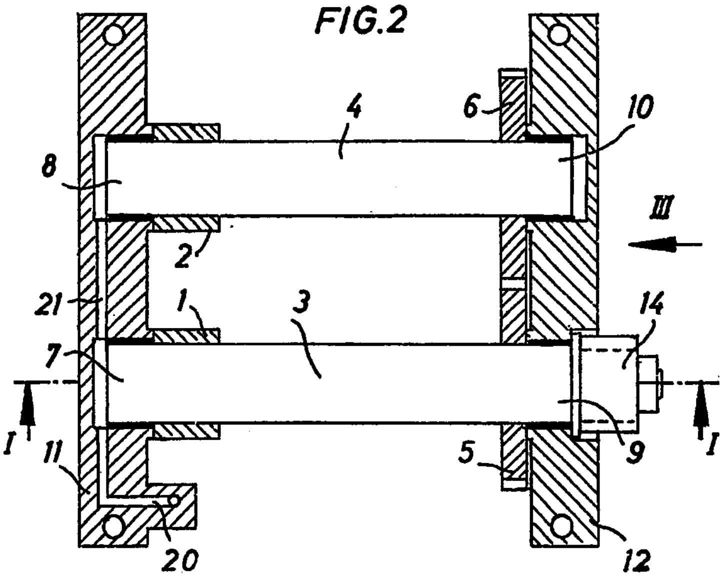


FIG.3